Battery Pack B-805805/64

65-T1a

BIDDLE

Application Guide for use of the

Radar Cable Test Set

MODEL 110-1 (CAT. NO. 655110-1)

and **PULSE AMPLIFIER** MODEL 111-1 (Cat. No. 655111-1)

on Communications Circuits

ESC-0284-92-01
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Permits

CAUTION
CHANGES HAVE BEEN MADE
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1/17/94

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Introduction

The purpose of this bulletin is to give overall instruction on the operation and application of the Radar Cable Test Set Model 110-1 and Pulse Amplifier Accessory Model 111-1. This set has gained wide acceptance in the Telephone, Power, Cable TV and Communications markets for identity and locating various types of fault conditions. The key to its usefulness is in the interpretation of the reflected signals. Like any type of test equipment, operation experience and familiartiy breed confidence in the set. It is the purpose of this technical paper to aid in this "familiarity" process.

Theory of Operation

The basic principle of operation is time domain reflectometry, also known as radar, pulse echo, pulse reflection and TDR. A pulse is generated on the line in the neighborhood of 2-10 volts peak, and when this pulse hits a discontinuity such as an open, short, splice, water in the cable, or any other type of inconsistency, a reflection is sent back. The type of reflection will indicate the type of fault and the time delay will give the distance to the fault. When the signal hits a higher impedance, such as an open, an upward deflection will result, and when it hits a lower impedance, such as a short, a downward reflection will result. Also, changes in capacitance of the cable caused by splices, water, and other inconsistencies will have typical traces which may be identified and located readily. The traveling speed of the pulse is directly proportional to the type of insulation in the cable and will vary with different types of insulating material. To accurately determine distance directly, these speeds are compensated for internally in the Model 110-1. To establish these propagation velocities several methods may be used. It helps to keep in mind that the Radar Set will not show anything that is not on the cable but likewise will show all inconsistencies, including some normal variations in the cable.

Radar Cable Test Set Model 110-1

3-1 Preliminary Instructions

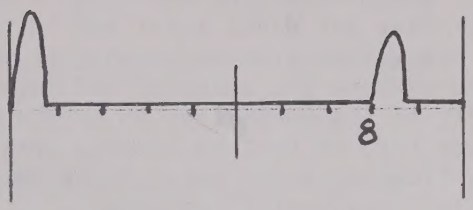
There are several factors which should be recognized when operating this set:

1. The Radar Set gives an electronic "picture" of the cable under test. If the basic operation of the set is understood, then the interpretation of the results will be easier.

2. The speed of the generated pulse in the cable varies with different types of insulation. In the Biddle Radar, we compensate for these various types of insulation by using preset positions on the dielectric control. In the event that the insulation material is not known, a known length of cable may be used to calibrate the insulation settings.

3. In reading the Radar Set, the reflected pulse is read as a percentage of the selected range. Example: Shown here we are on the 250 ft. range and we have an upward pulse at the 8th division, which indicates that we have an open 80% of 250 ft. or 200 ft. away.

Range - 250 feet



3-2 Operating Instructions

1. Turn the Switch marked ON/OFF/CHARGE to the ON position.

2. Adjust the intensity and focus controls for a clear, sharp trace.

3. If you are outside in sunlight, make sure the filter is placed on the CRT to avoid reflections or use the rubberized viewing hood. (Cat. #655118).

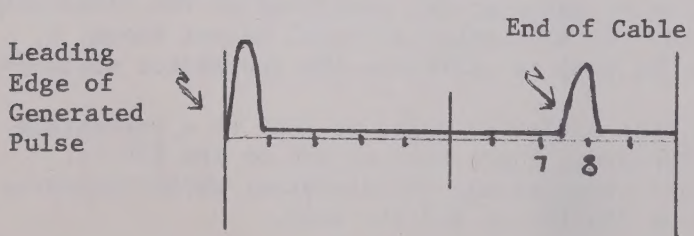
4. Turn the range switch to the range which approximates (???) (next higher than) ?? the length of cable to be tested. Example: For cable 400 ft. long, use the 500 foot range.

5. Set the cable dielectric control to the known dielectric position. If the insulation material is unknown, turn the dielectric switch to variable and proceed as follows:

   Take a known length of similar cable, say for example, 750 feet long, and adjust the Trace position so that the leading ed of the transmitting pulse is at the far left of the scope. Observe the trace and using the variable control, adjust the distance to the leading edge of the reflected pulse to 7.5. Assuming we're on the 1000 ft. range, this would read as 750 feet Now your set is calibrated to that type of insulation.

Range - 1000 feet

Dielectric - Variable



6. The Vernier control may be used to increase the accuracy of the Radar Set from ± 5% of range to ± 2% of range either when taking a reading or when calibrating. Again, using our 750 ft. cable calibration example in (5), set the Dielectric control to variable, the range to 1000 ft. Using the trace position control, we adjust the pulse so that the leading edge is at the center of the CRT. Turn the Vernier control to the right, you will see the trace move to the left. Keep turning the Vernier until you arrive at 7.50. Observe where the reflected pulse showing the end of the cable appears, and if it does not appear at the exact position as the original generated pulse, adjust it to that point using the variable control. In this example, the accuracy is increased from ± 50 ft. to ± 20 ft.

7. In using the Radar Set, if additional Gain (signal amplitude) is required, the x 5 switch may be turned on which amplifies the reflected pulses by a factor of 5. If additional amplification is needed, the pulse amplifier accessory Model 111-1 should be used. The following information outlines the use of this item:

Pulse Amplifier Accessory Model 111-1 (Cat. No. 655111-1)

4-1 Description

The Pulse Amplifier is an accessory unit which increases the capability of the Radar Cable Test Set and is normally mounted in the lid of the set. Sensitivity is increased by providing additional amplifier gain to x 100. Variable line balance allows the Radar Set to match the impedance of the line under test. The Pulse Amplifier has dual outputs and five different modes of operation.

4-2 When is the Amplifier needed?

Most telephone and communication applications need the Pulse Amplifier, however, Power and CATV do not. The amplifier should be used in the following situations:

a - when looking at long distances (greater than 6000 feet).

b - Where low-level faults are common.

c - When looking for difficult-to-find faults such as open bonds.

d - In comparing a good cable against a defective one.

e - When looking for splits and resplits.

4-3 Cable Connections

There are three cable connections on the Amplifier Unit: two output cables plus one cable to interconnect to the Radar Set. The latter cable also provides power to the Amplifier.

a - Output Cables: (one is supplied with Radar Set, the other with the Amplifier). Connect to Channel 1 and Channel 2; the clip ends are connected across the cable under test.

b - Interconnect Cable: Supplied with the Amplifier. This cable interconnects the Amplifier to the Radar; the small red leads are inserted in the power input plug on Amplifier and monitor plug on the Radar Set.

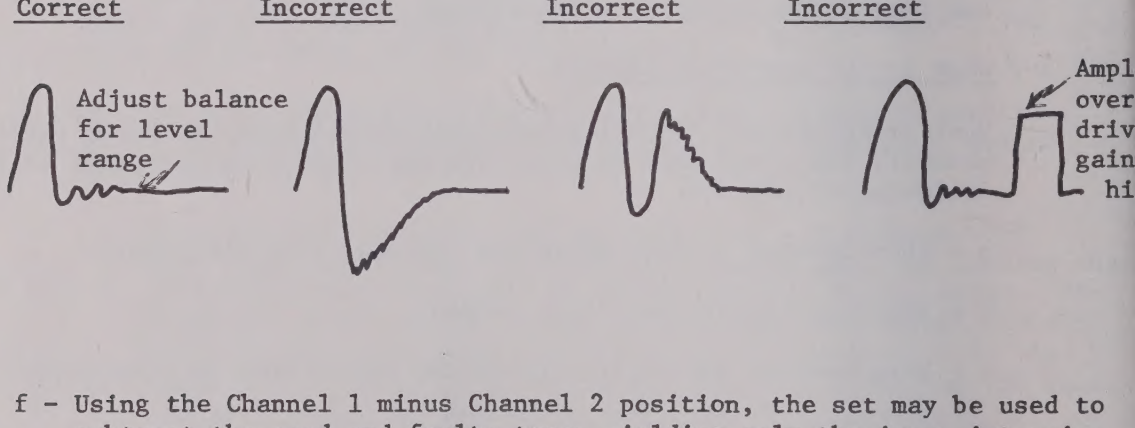
4-4 Operating Instructions

a - Attach the interconnecting cable to both the Amplifier and Radar Set, making sure that the red plugs are inserted into both the monitor plug in the Radar Set and the power input plug on the Pulse Amplifier.

b - Attach the output cables to Channel 1, and, if using in dual operation also Channel 2.

c - Turn the Gain x 5 switch on the Radar Set to the ON position.

d - To check one cable or one cable pair, turn to Channel 1 using the Mode selector switch. Using Channel 1 output leads, connect to the cable under test and adjust the Amplifier Gain so the reflections are not overdriven, i.e. have a square top to the reflections. The Line Balance should be adjusted for a level trace. The Amplifier Gain control should be kept as low as possible and yet high enough to see the reflections clearly. The distance to the fault and types of reflections should again be interpreted similar to the Radar Set operating instructions in Section 3-2. Note that there will be a 15 ft. delay in distance using the Amplifier.



f - Using the Channel 1 minus Channel 2 position, the set may be used to subtract the good and faulty trace yielding only the inconsistencies between the two pairs. Example: location of a low-level fault where we know one pair is good and the other pair is faulty. Here, the difference is taken between Channel 1 and Channel 2, and only the fault will show on the CRT.

g - Splits and resplits may be found by using Transmit Channel 1, Receive Channel 2 position. As stated, the pulse is transmitted on Channel 1 and is received back on Channel 2. At the points of cross-coupling, there will be a pulse upward or downward depending on the polarity of the leads, but for a resplit, the second pulse will always be in the opposite direction. To restate this, the first split will appear as an upward or downward pulse, and at the resplit, the opposite to that pulse will appear on the screen.

4-5 In summary, the only problem in operating the Amplifier will be the proper adjustments for the Gain and the Balance controls. The Gain should be adjusted so the reflections do not appear flat-topped where you are overdriving the Amplifier and the Balance control should be adjusted so there is a level trace following the transmitted pulse.

Applications

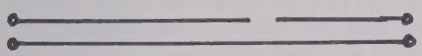
5-1 Introduction

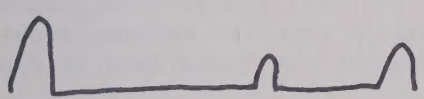
Communication applications are primarily involved with either twisted pairs or coaxial-type cable. The one requirement is that the cable has unform capacitance per unit length. The Radar Test Set may be connected between pairs or between pair and sheath. Communication applications of the Radar Set usually involve the following types of faults.

5-2 Open Conductors

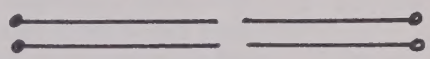
An open pair may be identified by a positive (upward pulse) occurring at the fault. If either conductor is open, a positive pulse will be returned. The amplitude of a single conductor open as in Fig. 1 will be less than if both conductors are open as in Figure 2. The end of the cable may sometimes be observed beyond a single conductor open depending upon the proximity of the fault to the end of the cable and also upon the wire gauge. (26 gauge wire gives the least amplitude since the energy is dissipated most rapidly due to the high resistance per mile). Maximum locating distance with 26 gauge wire is 8-10,000 feet due to the attentuation of the signal. In locating faults beyond 6,000 feet, it is generally advisable to use the Pulse Amplifier Model 111-1.

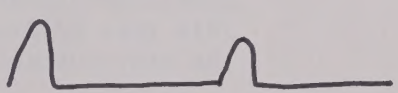
OPEN - ONE SIDE





OPEN - BOTH SIDES

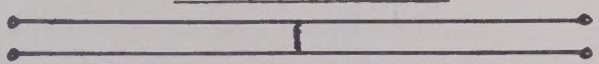


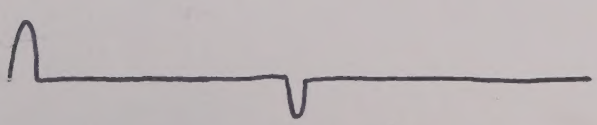


5-3 Shorted Conductors

A shorted pair will reflect a downward pulse at the point of the fault. All the energy will be reflected at this point giving a strong pulse. With a direct short, you will not be able to see the end of the cable.

SHORTED CONDUCTORS

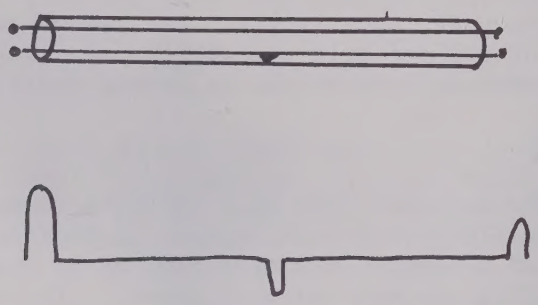




5-4 Short to Sheath

A pair of wires with a conductor shorted to the sheath will produce a negative pulse of lesser amplitude than a shorted pair because of the small additional capacitance introduced. Note that you see the short to sheath plus the end of the cable. Here again, the probability of seeing a reflection at the end of the cable will be determined by the proximity of the short to sheath.

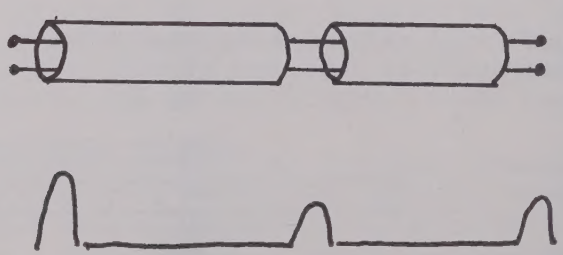
SHORT TO SHEATH



5-5 Open Sheath

An open sheath in buried communications cable can cause a variety of problems. It is a difficult fault to find and it is desirable to keep the test section of cable as short as possible. The test connections are made between a twisted pair and sheath. An upward reflection will appear at the open sheath. It is recommended that the range be adjusted so that the positive reflection from the open sheath is placed within the first 50% of the CRT by increasing the range, since this generates higher pulse energy and will result in a greater amplitude. This type of discontinuity usually requires maximum input energy for the best possible reflection due to the variations in capacitance.

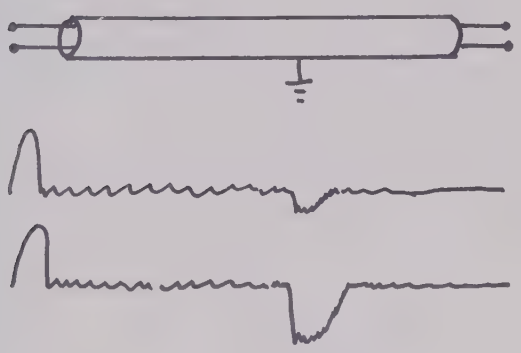
OPEN SHEATH



5-6 Grounded Sheath

A Grounded Sheath is a difficult fault to find. Note that the test connections are between a twisted pair and the sheath. The ability to find this type of fault will depend on several factors including the conductivity of the ground, the amount of moisture in the ground and whether or not each bond is securely grounded. A thorough understanding of the cable route is necessary in this case and again, the shorter the range, the better possibilities you will have in locating these faults. At the point of the ground, a downward reflection will occur, and as you will note in the figure, using the Amplifier, you get a much more identifiable reflection.

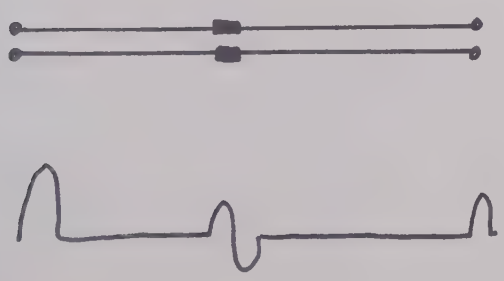
GROUNDED SHEATH



5-7 Splices

The splice represents a decrease in capacitance and inductance and appears as a small, rounded positive pulse followed by a small negative pulse. If the splice is defective, the peaks of the reflection will be much higher, especially if the splice becomes water-filled. A known splice may be used as a reference point to which a cable with an unknown dielectric may be calibrated by means of using the variable dielectric control.

SPLICE



5-8 Water in Cable

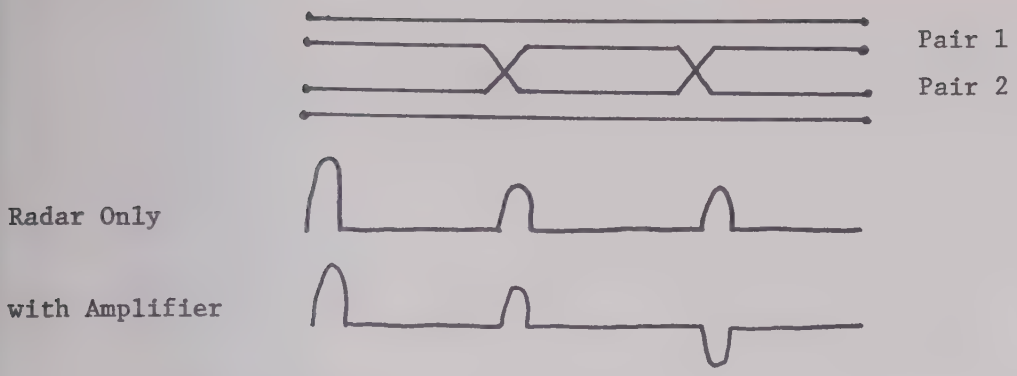
Crosses are usually due to water penetration into PIC cable. Crosses are typically found in direct buried cable and are due to damage to the insulation. When water is present between the pairs in the cable, the capacitance of the wet section changes drastically, and as a result the cable dielectric changes. The signal from the Radar Set "sees" this change in capacitance which causes a downward deflection at the start of the water and an opposite reflection at the end of the water soaked area. Also, if the water penetration is not consistent, a ragged trace may appear as shown in the second figure. A third possibility is shown in the third trace where the cable is wet at the point of the test connections. Here you will see a ragged trace and depending on the length of the water-soaked area, there is a chance that you will not be able to see where the cable goes from wet to dry. The accuracy of measurement is to the boundary of the water due to the fact that the signal slows down while it is in the water-soaked area and, as a result, the wet section may appear to be as much as 60% longer than actual. Therefore, to accurately locate the limit of water penetration, it is necessary to measure from the opposite end so you can establish boundaries on both sides.

WET CABLE

5-9 Splits and Resplits

Traditionally, these faults have been very difficult to find especially in direct buried cable. At the point of the split, there will be evidence of a discontinuity, either an open or a short, depending on the polarity of the test leads. If a split and resplit is suspected, use the amplifier turned to the transmit Channel 1-Receive Channel 2 mode of operation, and connect test leads to the pair that is split and the suspected pair that is resplit. As noted before, there will be either a positive or negative pulse at the split, depending upon the polarity of the test leads, but where the resplit occurs, there will be a definite deflection in the opposite direction as in the original reflection. As you can see in the two figures, the first trace shows the appearance of two opens with radar only. The second trace shows, using the amplifier, the initial upward reflection followed by the opposite downward reflection which definitely identifies a resplit.

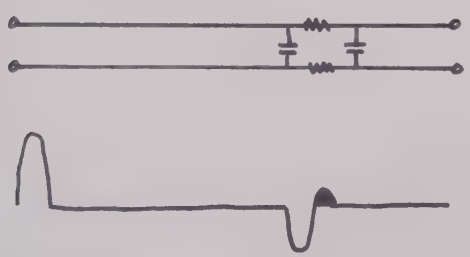
SPLITS AND RESPLITS



5-10 Capacitor Build-Outs

Capacitor build-outs are added to cables to create the electrical standard spacing for load coils of 4500 ft. in REA systems and 6000 ft. in Bell Systems. These build-outs have a cut-off frequency of approximately 3-4 KHz, and consist of capacitors and resistors. The value of capacitance is based on .083 uF/mile, and the value of the resistor is based on the gauge of the wire. Capacitor build-outs will appear as a direct short to the Radar Test Set and will have a degree of overshoot depending on the capacitance value.

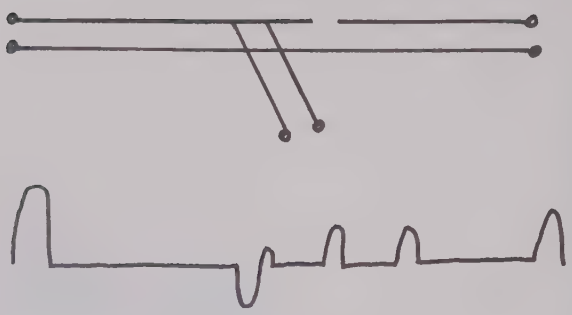
CAPACITOR BUILD-OUTS



5-11 Bridge Taps

At the point of the bridge tap, a downward pulse occurs having a negative amplitude with a positive overshoot directly proportional to the tap length. From the point of the tap on, the two traces will overlap, and as you can see, the end of the cable T1 and the end of the cable T2 appear as one trace along with the short to sheath. To verify a problem on the T2 leg, it would be necessary to connect the test set at points T2 and look back towards cable T1.

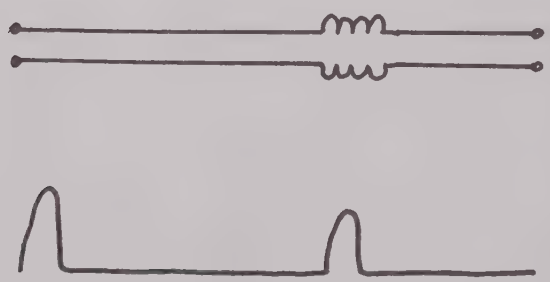
BRIDGE TAPS



Loading Coils

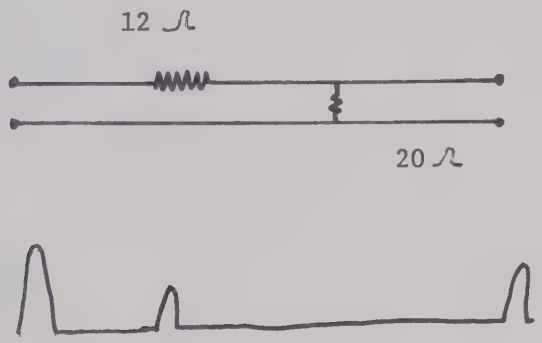
The Radar Test Set cannot look through load coils since they appear as an open circuit to the high frequency pulse. It is possible to trouble-shoot loaded circuits by shooting from alternate loads taking 6000 ft. sections in consecutive order from a load coil position. Using this procedure, it is not necessary to disconnect the load coils since they are an open circuit, and will appear as an upward reflection. The Radar Set is useful in clearing lines of bridge taps, capacitor build-outs and loading coils for T carrier. If any of these are present, they will be shown on the Radar Set and the location to each readily determined.

LOAD COIL



5-13 High Resistance Faults

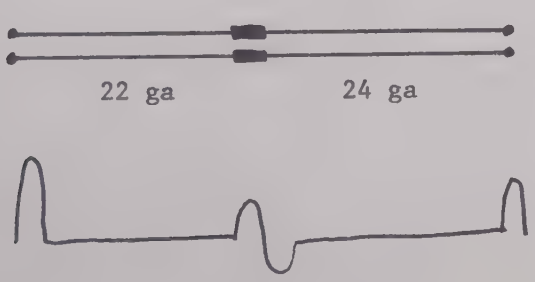
High Resistance Series FAults can be easily seen by the Radar Set and will appear as an open, (Figure 1). On the other hand, High Resistance Shunt Faults cannot be seen by the Radar Test Set. When the signal hits the high resistance shunt-type fault, it is looking at the relatively low resistance towards the end of the cable versus the extremely high shunt resistance, and as a result, no reflection occurs at that point. It is difficult for the Radar Test Set to see any shunt resistance much over 5000 ohms.



5-14 A Change in Wire Gauge

At the point of a change in wire gauge, say from gauge 22-24, an upward reflection will occur due to the decrease in wire size and increase in wire resistance. In actuality, you see the point where the wires are spliced together. The propagation velocity will change 1% per change of wire gauge number. In this case, the gauge changed by 2%, meaning a 2% change in propagation constant, and a 2% error in the distance reading. The effect on readings is relatively small and much less than in bridge-type measurements which are affected more by a change in wire size.

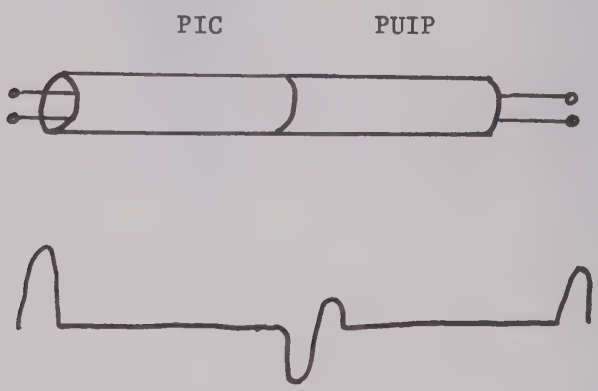
CHANGE IN WIRE GAUGE



5-15 A Change of Insulation Material

A change from PIC to Pulp, for example, also results in a reflection. In this case, the propagation velocity will increase producing a decrease in surge impedance yielding a negative pulse. Pulse amplitudes are usually small (less than at bridge taps). Offsetting pulses will be generated if the wire gauge increases along with a simultaneous change from PIC to Pulp. The VPC is effective per the formula VPC = $1/\sqrt{e}$ where e = the dielectric constant of the material. Distance measurements are accurate for each section as long as the dielectric is set to the section being measured. Example: Measuring on a cable that is half PIC and half Pulp. Looking toward the PIC half, the setting should be only Poly and opposite for Pulp.

CHANGE IN INSULATION



6. Velocity Propagation Coefficients (v.p.c.)

The VPC or Velocity Propagation Coefficient is that value which defines the speed of an electrical signal relative to the type of insulation of the cable.

6-1 Typical Values

Material	v.p.c.	Material	v.p.c.
Vacuum	1,000	Pulp (0.83 uF/mile)	0.720
Air	0.98	Pulp (Low capacity 0.72 uF/mile)	0.880
PTFE (Teflon)	0.710		
PIC (0.83 uF/mile	0.667	PILC (Paper insulated, lead covered)	0.500 to 0.560
Paper	0.54 - 0.74	XLPE (Cross link poly)	0.520 to 0.580
		HMW (Hi Molecular weight)	0.560 to 0.620

6-2 Dielectric Constant Known

a. Calculate the velocity propagation coefficient (v.p.c.)

$$v.p.c. = \frac{1}{\sqrt{e}}$$ where e is the dielectric constant

6-3 Propagation Velocity Known

a. Calculate the velocity propagation coefficient (v.p.c.)

$$v.p.c. = \frac{V}{C}$$

where: C = velocity of light in free space = 984 ft/us

V = propagation velocity of cable in ft/us.

6-4 A Short Sample Length

a. Measure the length (ft) capacitance (pF) and inductance (uH).

b. Calculate the velocity propagation coefficient (v.p.c.)

$$v.p.c. = \frac{\ell}{0.984\sqrt{L\,C}}$$

where: C is in picofarads

L is in microhenries

ℓ is in feet

6-5 A Sample length 60 ft.

a. Measure the length of the cable.

b. Connect the sample cable to the PULSE OUTPUT socket.

c. Set CABLE DIELECTRIC switch to VARIABLE and adjust the VARIABLE contr so that the reflection from the end of the sample cable occurs at the equivalent length, as measured either on the graticule or the VERNIER.

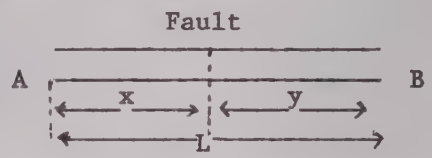
d. This calibrates the VARIABLE control for all ranges, for that particul type of cable.

e. Connect the cable to be examined and measure distance-to-fault.

6-6 Known Route Length both Ends Accessible

a. Set the CABLE DIELECTRIC switch to FOAM.

b. Measure the apparent distance-to-fault from end A and from end B. Calculate the distance-to-fault (d) from end A:



Where: L = route length of cable

x = apparent distance-to-fault from end A

y = apparent distance-to-fault from end B

Biddle Instruments cover a wide Range of Applications

MAJOR MEGGER® INSULATION TESTERS

Dependable multi-voltage, multi-range testing instruments that have become the byword of insulation testing. Choice of Hand-crank, line-operated or Dual operated models.

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HEAVY-DUTY MEGGER® INSULATION TESTERS

Two new dual-operated models available: one with range of 250,000 MΩ at 2500 V, output volts from 500 to 2500 V in 5 ranges; a second model has range of 500,000 MΩ at 5000 V, output volts from 1000 to 5000 V in 5 ranges.

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We have faced a variety of Partial Discharge application problems in every industry from cable manufacturing to aerospace. We have designed instruments for Partial Discharge measurements, power supplies for use with these instruments, and complete systems covering a wide range of applications for Laboratory Research and Production Quality Control, even a fully programmable Partial Discharge test set keyed to digital printout.

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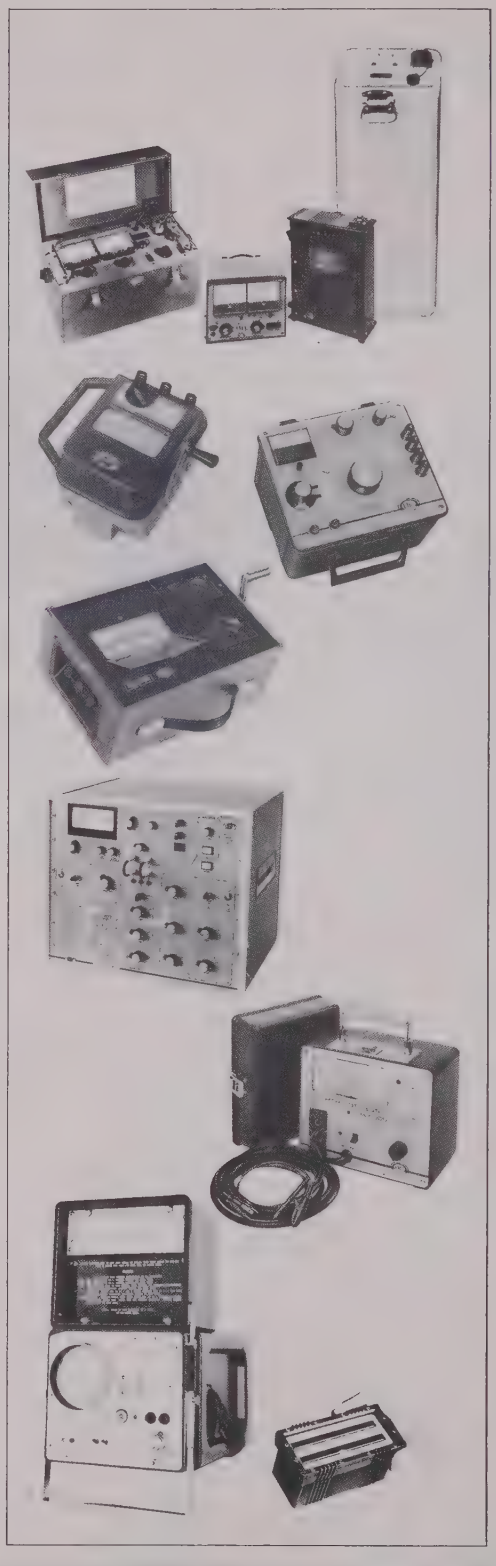

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Sales representatives in principal cities

Printed in U.S.A.

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BIDDLE CME-110A CABLE TEST SET AND CME-111 PULSE AMPLIFIER DESCRIPTION AND MAINTENANCE

CONTENTS PAGE

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. DESCRIPTION 1
Accessories 2
Carrying Case 2
. MAINTENANCE 2

. GENERAL

.01 This section describes the Biddle Model CME-110A Cable Test Set, and Model CME-111 Pulse Amplifier mounted inside the cover of the test set. Combined, these sets will locate and test faults in telephone and CATV cables.

. DESCRIPTION

.01 The cable test set (Figure 1) is a portable transistorized test set 7-1/8 inches high, 3-5/8 inches wide, 16-1/4 inches long, weighing 3-1/2 pounds without batteries (17 pounds with batteries). It will operate from an internal 13.5Vdc rechargeable battery or an external rechargeable battery (11Vdc to 15Vdc at 700 ma) or from a main source (110Vac or 230Vac, 45 Hz to 550 Hz) power supply.

.02 The cable test set, without the pulse amplifier, will test coaxial cables, feeders, multicore cables, cables located underground when carefully installed and spaced for uniform impedance, and inside closed trunking.

.03 The pulse amplifier (Figure 2) mounted on the inside of the cover is 6-3/4 inches high, 8 inches wide, 5-1/2 inches deep, and weighs approximately 2-1/2 pounds.

.04 The pulse amplifier, used in conjunction with the cable test set (Figure 3), increases the sensitivity of the test set up to 100 times, making it possible to locate faults in all types of telephone and CATV cables, and compare faulty cables with good cables for locating high impedance faults. It simultaneously displays the reflections of two cables, subtracts the reflections of one cable, and displays the difference from another cable. It also enables the mis-matches (caused by cross-coupling between two pairs of cables of a multicored cable) to be displayed on the test set.

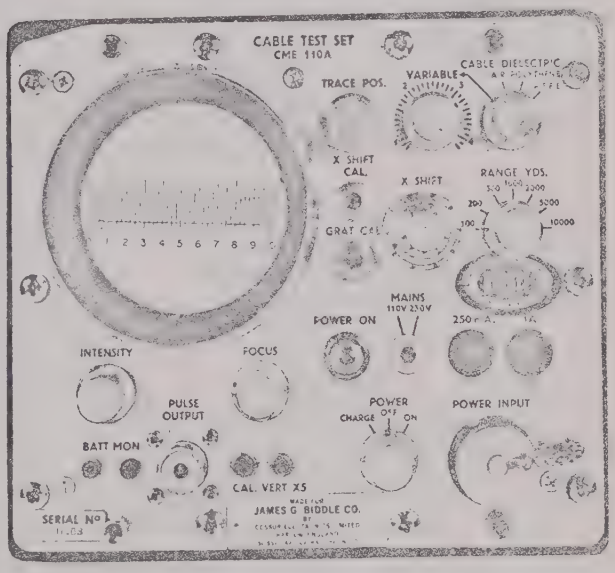

Figure 1. Model CME-110A Cable Test Set.

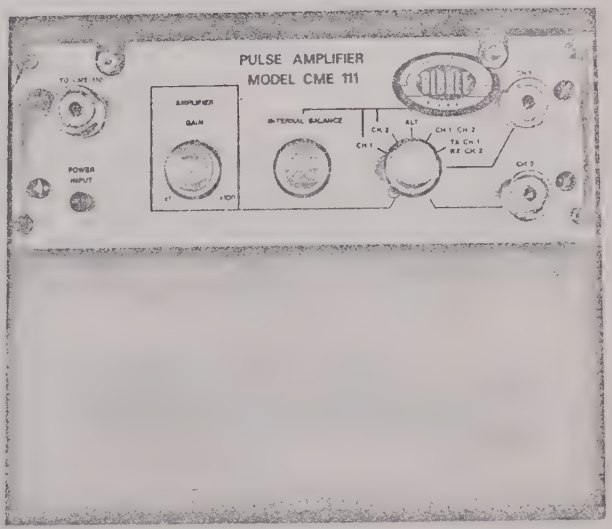

Figure 2. Model CME-111 Pulse Amplifier (Mounted in the Lid of Model CME-110A Cable Test Set).

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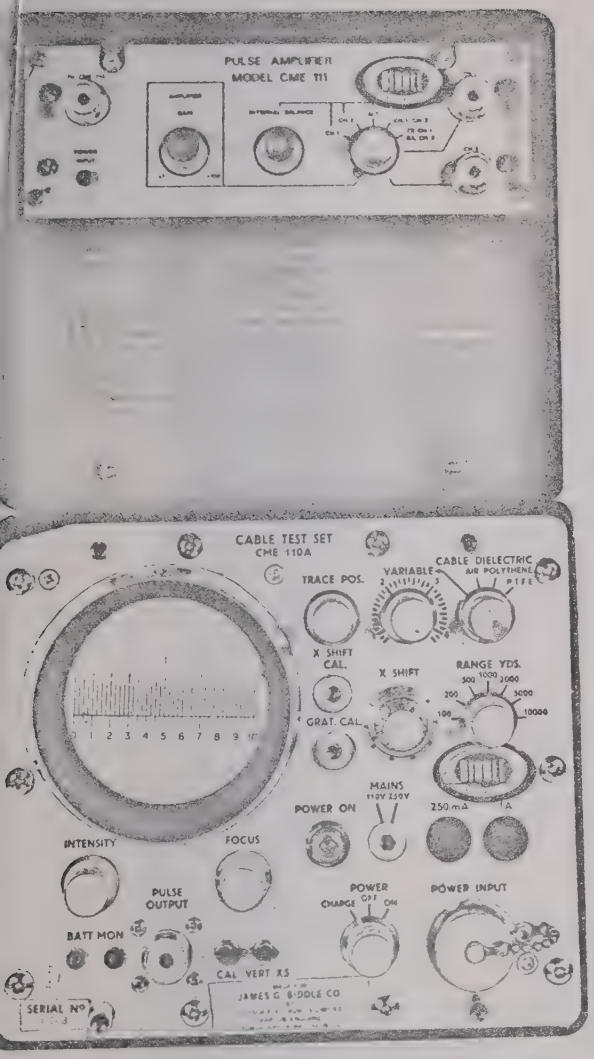

ure 3. Model CME-111 Pulse Amplifier Combined with Model CME-110A Cable Test Set.

Accessories

05 The Model CME-110A Cable Test Set is supplied with the following cables (Figure

(a) One 5-foot UR-70 (UHF) coaxial cable, terminated at one end with a plug for connection to the PULSE OUTPUT jack on the test set, and terminated at the other end with alligator clips to connect to the cable being tested.

(b) One input power cable, terminated at one end with a plug for connection to the POWER INPUT receptacle of the test set, and terminated at the other end with a plug for connection to the main power supply.

2.06 The Model CME-111 Pulse Amplifier is supplied with the following cables:

(a) Two 5-foot UR-70 (UHF) coaxial cables.

(1) One cable is terminated at one end with a plug for connection to the CH.1 jack on the pulse amplifier, and terminated at the other end with alligator clips to connect to the cable being tested.

(2) The second cable is terminated the same way as the first cable, except that the plug end of the cable connects to the CH.2 jack on the pulse amplifier.

(b) One interconnecting cable (UR-70), terminated at both ends with plugs, to interconnect the POWER INPUT jack of the pulse amplifier and the PULSE OUTPUT jack of the cable test set.

NOTE: When this cable is used, the 5-foot UR-70 cable supplied with the Model CME-110A Cable Test Set is not used.

Carrying Case

2.07 A tough waterproof carrying case (Figure 5) provides for storing and carrying the test set with or without the pulse amplifier mounted inside the cover.

3. MAINTENANCE

3.01 Maintenance instructions presented in the following paragraphs cover battery cell replacement.

3.02 If the battery registers 12V or less, it must be re-charged. A fully-charged battery will register 13.5V and have 5-hours of life for field use.

.03 When the test set has not been used for a long period of time, and the battery shows a ow capacity, run the battery down to 11V, and ive it a full 14-hour charge. If the low capacity till exists, repeat the 14-hour charge.

3.04 If the battery voltage registers below 11V or the test set screen shows low brilliance and the pulses jitter, the battery may be damaged due to a faulty battery cell.

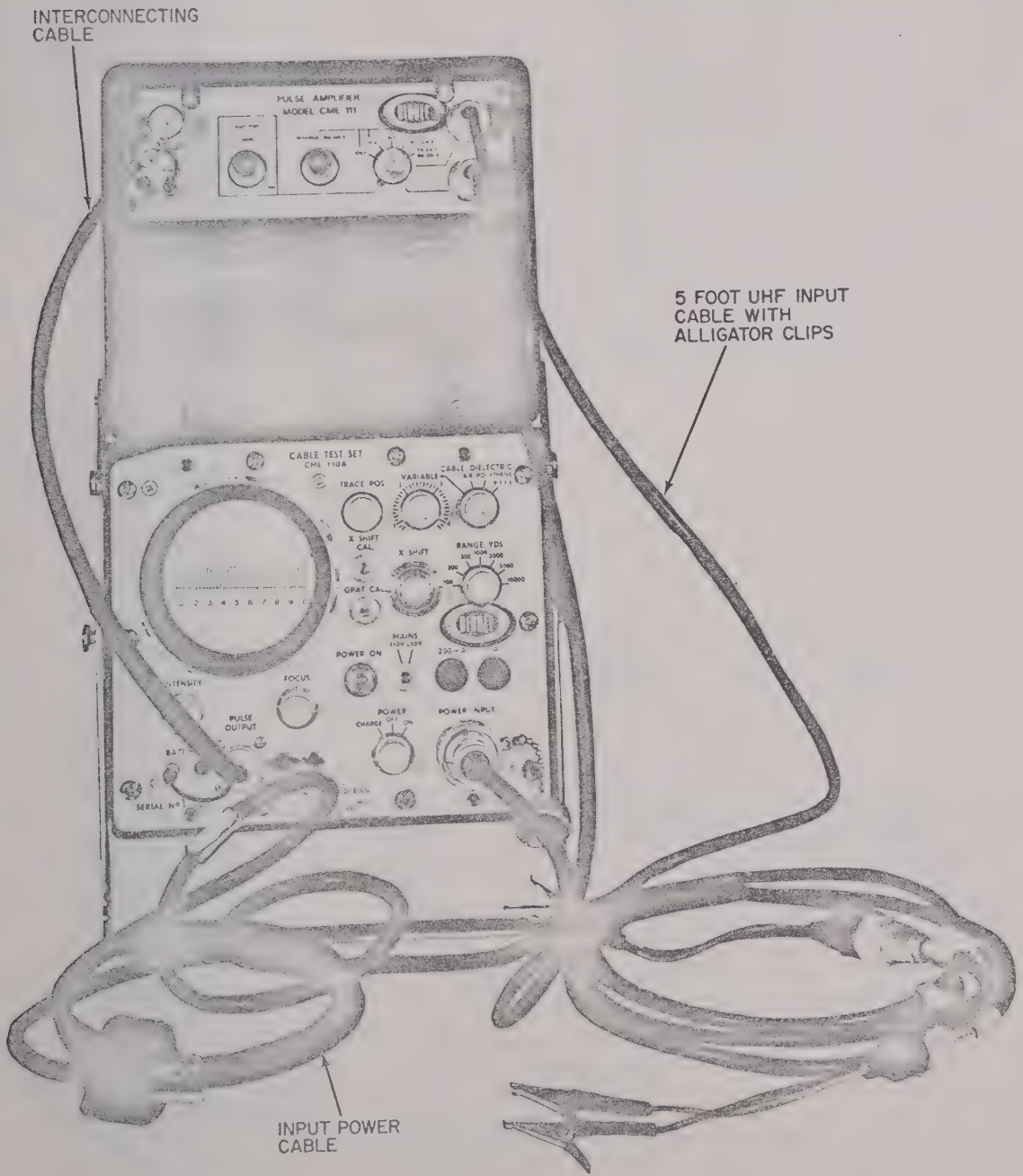

Figure 4. Cable Test Set and Pulse Amplifier with Connecting Cables.

When a faulty battery cell is to be replaced, remove the battery box (Figure 6) from the t as follows:

(1) Unscrew and remove the four screws that fasten the lid on the back of the test set.

(2) Pull out the battery box, using the finger pull.

Figure 5. Waterproof Carrying Case.

(3) Disconnect the two plugs connected from the test set to the battery box.

(4) Place the two plugs in the dummy sockets at the rear of the battery compartment in the test set.

(5) Unscrew and remove the two captive screws from the top of the battery box and remove the lid.

(6) Wipe off any leakage from the foam lining in the lid.

(7) Unsolder the lead from the top of the cell that is being replaced.

(8) Trace the wire soldered to the bottom of the cell that is being replaced to the cell next in sequence.

(9) Unsolder the wire from the top of the cell next in sequence.

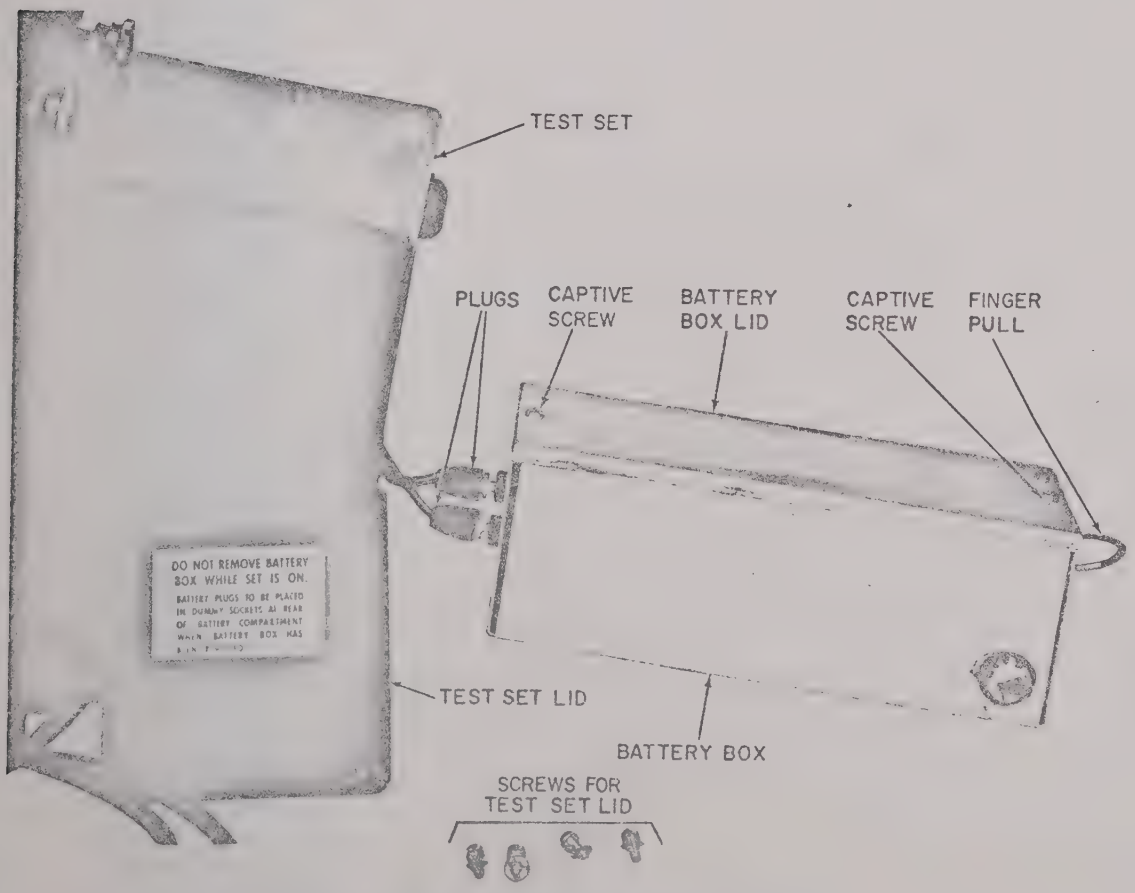

Figure 6. Removing Battery Box From Test Set.

(10) Lift the loose end of the wire attached to the battery cell out of the battery box.

(11) Solder a piece of 23/36 Type 3 wire 6-inches long to the bottom of the new battery cell.

(12) Insert the new battery cell in place of the cell that was removed.

(13) Solder the wire attached to the bottom of the new cell to the top connection of the battery cell next in sequence.

(14) Solder the remaining loose wire to the top connection of the new battery cell.

(15) Place the lid on the battery box and fasten the two captive screws.

(16) Remove the two plugs from the dummy sockets of the test set and connect them to the battery box (Figure 6).

(17) Slide the battery box into the test set.

(18) Replace the lid of the test set and fasten the four screws.

NOMINAL DISTANCE CAL SETTINGS FOR TYPICAL CABLES	
CABLE TYPE	SETTING
Air	.98
Air Spaced Coax	.94
Foam Poly	.82
Teflon	.71
PIC (.083 uF/mile)	.67
Pulp (.083 uF/mile)	.72
Pulp (.072 uF/mile)	.88
Jelly Filled PIC	.64

For maximum accuracy, determine exact DISTANCE CAL settings by calibrating the instrument using a known length of cable.

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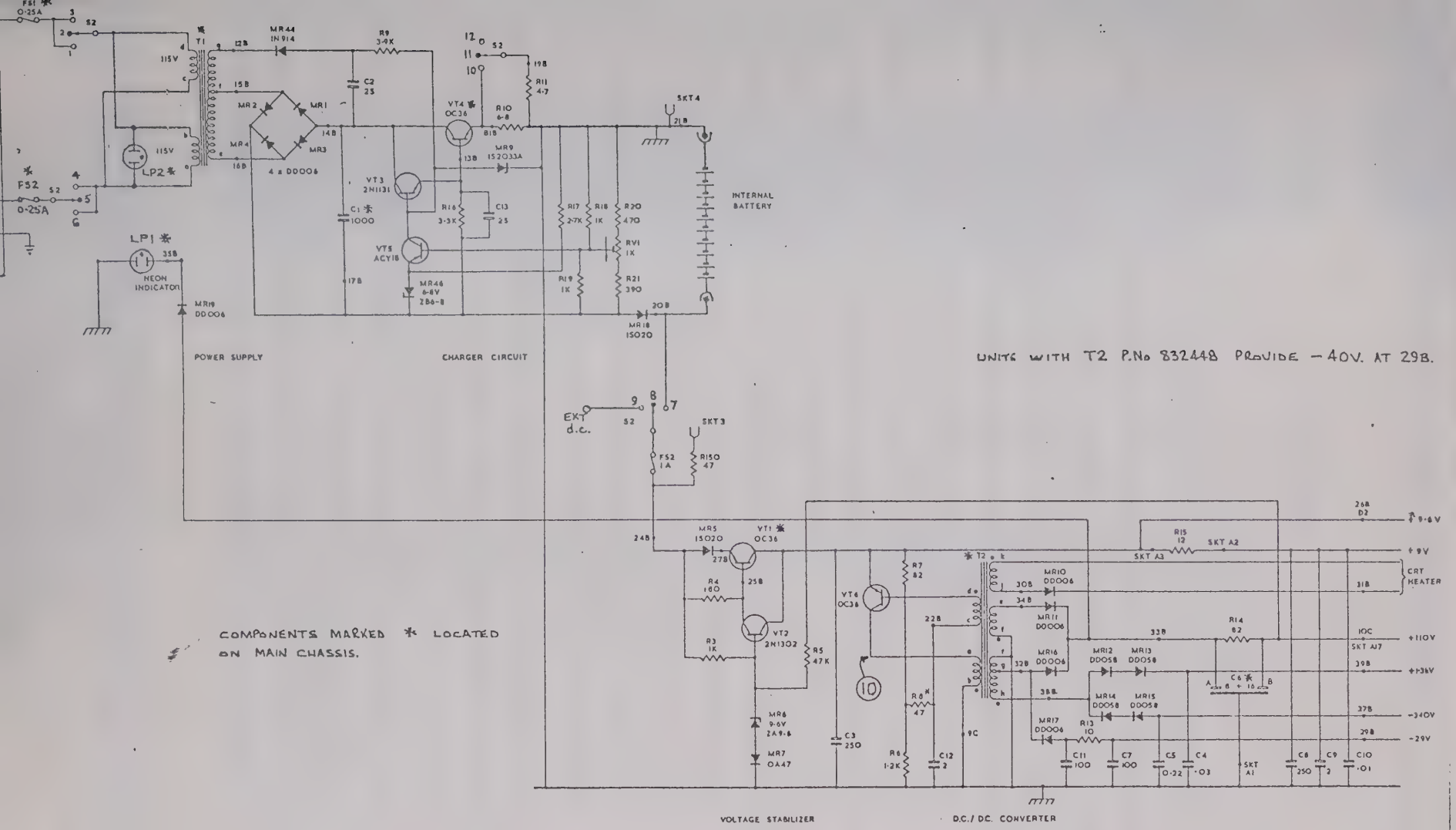

CIRCUIT DIAGRAM CME 110A-1 POWER SUPPLIES 'PCB B'

Fig. 6-2

Top 100 Parts

rt No.	Description	Where Used	LIST PRICE
245	Field Calibrator	250260	$ 55.00
350-6	Generator Assy	210159	195.00
350-7	Generator Assy	21159	195.00
363	Ammeter for 55003 TTR Instrument	550005	65.00
364	Voltmeter	550005	65.00
365	Galvanometer	550005	65.00
432	Window	21159	5.00
438	Case	21159	10.00
586	Output Cable	210400	75.00
997-1	Case Lid	720350	35.00
998-1	Case Bottom	24, 72 etc.	25.00
999-1	Case Standard Lid	247000	25.00
999-2	Deep Lid	247000	25.00
166-2	Terminal	21159	7.00
874	Meter	72-311, 577500	90.00
883	Meter	72-439	90.00
119-13	On-Off Switch	21259	20.00
119-14	Switch	247000	20.00
119-15	Power Switch	247000	25.00
119-16	Switch	247000	20.00
119-19	Power Switch	218638, 40	30.00
766-1	Cable Assembly	651027-1	325.00
833-1	Modf'd Communication Headset	651103	165.00
03-111	6-32+2 5/8 Flat Steel Zinc Screw	21159, 210159	.25
344	Line Cord	21359, 655110-1	12.00
440	Meter	72-326	65.00
61-45	1/4 Hex Steel Zinc Nut	21159, 210159	.25
243	Megohmmeter (Ammeter)	210400	250.00
244	K V Meter (Voltmeter)	210400	135.00
877-6	Knob Assy	720360-2	15.00
911	Line Cord	72-350	10.00
004	Battery Pack	72-320	70.00
553	Switch	247000	75.00
568-1	Rechargeable Battery - 4 required	247000	12.00
568-2	Rechargeable Battery - 2 required	247000	20.00
568-4	Battery (218650) - 2 required	218650	65.00
569	Meter	247000	35.00
790-1	Overlay	720350-2	20.00
7032	Input Line Cord	218638, 210559, 655333, 655435	12.00
8035	Output Cable	220120, 220160-1	295.00
8305	Receptacle	218638	8.00
8310	Meter	220070	225.00

art No.	Description	Where Used	LIST PRICE
18313	Bag Cable Carry Canvas	220120, 220160-1	60.00
18352-1	Transformer	220120	575.00
18352-2	Encapsulated Transformer	220160-1	575.00
18600	Battery Pack	720350	75.00
18608-1	Display	720350	65.00
19108-3	Transformer Power PC Mntd.	720350	45.00
19114	Case (Modified)	250260	12.00
19268	Cover Ass'y	651028	165.00
19650	Transformer Assembly	550005	265.00
19937-1	Bezel Mount Kilovoltmeter	651028	130.00
19937-2	Bezel Mount Kilovoltmeter	651028	130.00
22389-4	Lid Assy	230305	35.00
22780	Transformer Special	210159	25.00
23206	Moving System W/Scale	210159	75.00
23210	PC Board Assy	210159	300.00
23563	Pulse Output Cord - 5 Ft.	655110-1	45.00
23664	Battery Pack (400)	655431, 433, 435	125.00
23667	Battery Pack	655333, 335	125.00
23688	Digital Panel Meter	247000	375.00
2457	Anvil Assembly	55003, 550005	35.00
25209-4	Cover	210459	15.00
2541	Fuse Holder	247000	8.00
2544-1	Fuse - 100 MA 5 x 20 MM	21805, 21805-1	4.00
25601-6	Probe & Bearing	247000	75.00
2567-2	Fuse - 1 Amp 250V	210159	2.50
2567-20	Fuse	247000	2.50
2567-9	Fuse	247000	6.00
26999	Thermal Printer Paper	218701	10.00
2756	"C" Clamp (Pair)	55003, 550005	75.00
2798	Lead Clamp Assembly	55003	195.00
3140	Rubber Foot	218638	4.00
3447	DC Plug Unwired	655333, 335	5.00
4702	Ground Cable Assembly	220005	65.00
5026	Wing Nut	247000	2.00
5119	Pin	247000	1.00
5599	Bumper	21159, 210159	.50
653442	Output Cables/Pair	655335, 655435	125.00
653443	Single Output Cable	655333, 433, 431	45.00
653445	Pkg. of 20 Overlays	655333, 335, 431, 433, 435	10.00/Pk.
653446	Marker Pen for Overlays	655333, 335, 431, 433, 435	5.00
6576-3	Voltmeter	651027-1	145.00
80585/84	Battery Pack	655110, 655110-1	200.00
9091	Nut	247000	4.00
BC183	Transistor	218650	8.00

o.	Description	Where Used	LIST PRICE
3	Transistor	218650	8.00
6	Transistor	218650	20.00
6617021	Battery Pack	655535	250.00
514	Lid (300-400)	655333, 335, 431, 433, 435	135.00
4141068	Battery Pack 300	655333, 655335	295.00
4141072	CRT (333-335)	655333, 335	1600.00
5273092	CRT	655431, 435, 435	1600.00
5273131	Battery Pack	655431, 433, 435	250.00
400-013	Mushroom Buffer	21805, 21805-1	5.00
10-174	Front Cover	21810	35.00
10-118	Carrying Handle	212159	12.00
20-824	Movement (21805)	21805	225.00
20-825	Movement (21805-1)	21805-1	225.00
21-038	Movement	218640	1500.00
21-039	System SL	218638	1500.00
21-101	Movement	210800	95.00
21-107	Movement	21822	105.00
21-197	Crank Handle Assy	212159	15.00
21-219	Movement	212359	85.00
21-221	Movement (10396-7)	212159	85.00
21-170	Switch (Scale)	218638	65.00
30-104	Amplifier P.C.B.	218638, 40	225.00
30-337	Thick Film Hybrid (6180-203)	210800	75.00
30-753	Crank Handle	218638	275.00
30-460	Cover Assy (Lt. Gray)	21805, 21805-1	45.00
30-518	Case Bottom (Blue)	21805, 21805-1	55.00
30-524	Circuit P.C.B. (21805)	21805	95.00
30-525	Circuit P.C.B. (21805-1)	21805-1	95.00
30-592	Cover	21822	35.00
30-873	HI-Voltage Switch	218638	85.00
31-036	Movement	21810	295.00
31-250	Movement 218650	218650	245.00
30-061	Meter 241	250241	225.00
-1	Movement	21159	225.00

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